Spin-echo resolved grazing incidence neutron scattering (SERGIS)

Scientific Achievement

We developed a novel neutron scattering instrument aimed at measuring the in-plane structure of thin films such as artificial bio-membranes, block-copolymer films, and lubricating or adhesive layers at length scales between 10 nm and 1000 nm. Toward that goal, we assembled a prototype instrument by equipping with Neutron Resonance Spin-Echo (NRSE) circuits the EVAnescent wave polarized neutron diffractometer at the Institut Laue-Langevin in Grenoble. In that instrument we adopted the technically well-developed NRSE method to demonstrate the range of scientific problems to which SERGIS is applicable. The SERGIS concept is based on encoding by neutron spin echo one component of the neutron momentum transfer – regardless of the resolution of the initial and final momentum. Thus the technique not only dispenses with slits and collimators thereby overcoming scattering-power limitations but is capable of resolving correlation between particles with much higher accuracy than conventional scattering methods. This was demonstrated in a series of experiments in transmission geometry, by probing the structure of pores in anodized aluminum, and in reflection geometry, by determining the correlation between polymer droplets dewetted from a silicon surface.

Significance

The sum of technical and scientific experiences thus accumulated provides the basis for the design of a second-generation unit. At the same time we are developing a novel technology, based on Larmor precession of neutron spins in thin magnetic films, which will complement or supplant NRSE at the Spallation Neutron Source. We envision an instrument in which encoding of one component of the momentum transfer will enable the measurement of diverse phenomena such as the long wavelength undulations that might be present in biological membranes and the surface fluctuations (capillary waves) of a liquid surface and also the study of large scale structures, such as those present in sedimentary rocks or colloids or biological membranes.

Performers

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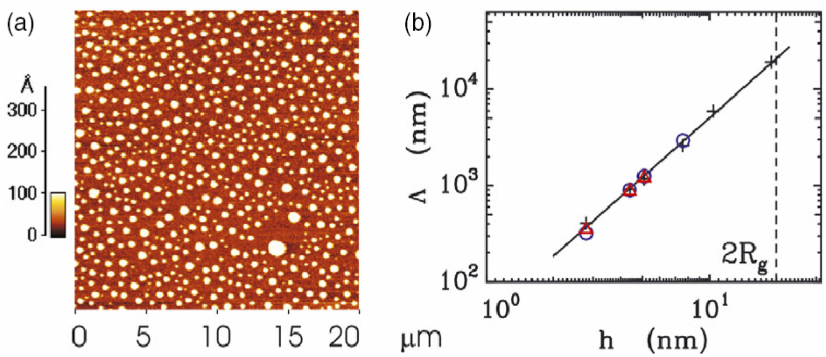
Spin-echo Resolved Grazing Incidence Scattering

…from polymer droplets on silicon

To test the power of the technique in observing correlation of small objects at surfaces and interfaces

AFM image

height versus diameter



Arrays of polymer droplets on the surface

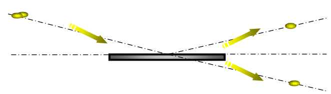
Height of droplets ~10 nm

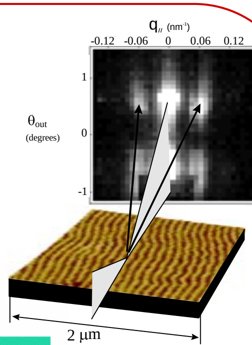
Distance between droplets ~ 500 nm

Three types of droplets

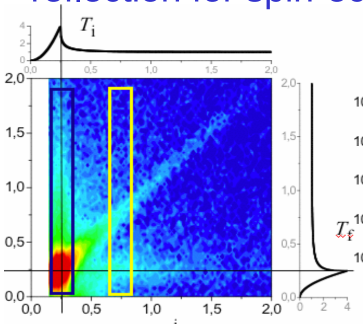
Black	pure polystyrene
Red	polymer
Yellow	copolymer

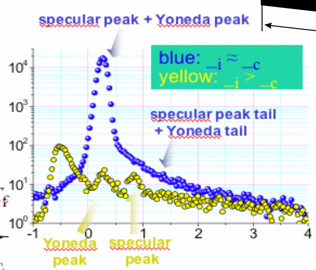
Scattering Geometry



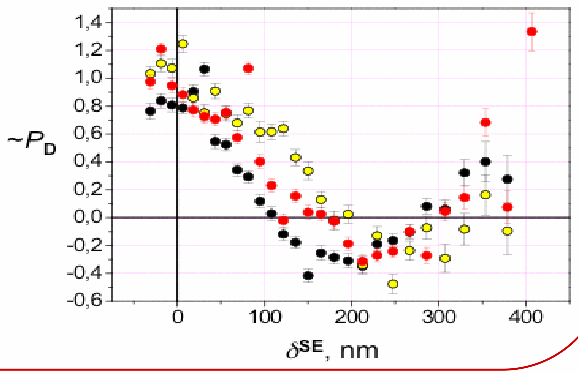


Separating diffuse from specular reflection for spin-echo analysis





Correlation between droplets from spin-echo analysis



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